FIRST Motors

Which one do I use??

21 November 2002

How to Determine Which Motor to use for a Task

- Force?
  - How much force is required to move the system?
- Distance?
  - How far does the system have to move?
- Speed?
  - How fast does the system need to move?
- Motor Power = Force * Distance / Time

What is Power?

= Work / Time
= Force * Distance / Time
= Watts
= ft * lbs / min or N * m / sec
= Torque * Angular Velocity

- Example: lift robot 6 inches in 2 seconds
  - 130 lbs = 580 N, 6 inches = .15 meters
  - 580 N * .15 m / 2 seconds = 43 Watts

Gear Ratio and Efficiency

- Gear Ratio = Torque Needed / Available
- Effective Gear Ratio
  = gear ratio * efficiency
  - Example
    - Torque Needed = 45
    - Torque Available = 15
    - Gear Ratio = 3
    - Gear Efficiency = 90%
    - Effective Gear Ratio = 3*.9 = 2.7

Multiple Gear Ratios and Efficiency

- Say you have Two gear ratios of 3:1 and a 90% efficiency for each, what is the overall effective gear ratio?
- Effective Gear Ratio
  = 3 * 0.9 * 3 * 0.9
  = 7.3 (not 8.1)
- If need 50 Watts over these gear ratios
  = 50 * 0.9 * 0.9
  = 40.5 Watts

Motor Characteristics

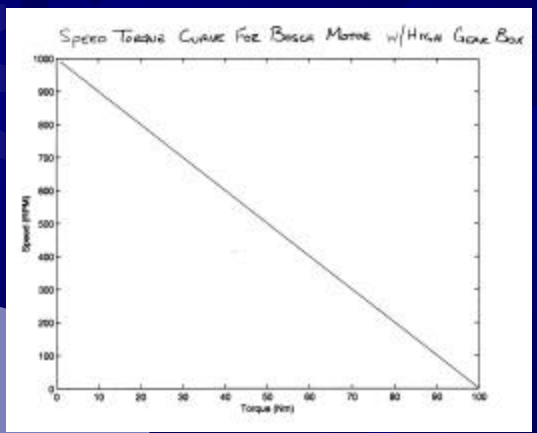
- Stall Torque
- Stall Current
- Free Speed
- Free Current
- Peak Power
- Gearbox Ratio
- Gearbox Efficiency

Motor Specs

Kit Description	Gearbox Ratio	Gearbox Efficiency	Peak Power	Operating at stall		Operating with no load		Operating at max. outout		
				Torque	Current	Speed	Current	Torque N-m	Speed	Current
Drill Motor, motor only	-	-	340 W	0.65N-m	114 A	20,000 RPM	2.5 A	0.325	10,012	58 A
Gearbox in "high" powered by drill motor	20:1	80%	260 W	10 N-m	114 A	1,000 RPM	2.5 A			
Gearbox in "low" powered by drill motor	64:1	70%	230 W	29 N-m	114 A	300 RPM	2.5 A			
Fisher-Price, motor only	--	--	149W	0.38 N-m	57 A	15,000 RPM	1 A	0.19 N-m	7,500	37.5 A
Fisher-Price, motor/gearbox	147:1	65%	91 W	35 N-m	57 A	100 RPM	un			
BOSCH Van Door Motor - Bosch - right hand side motor	--	--	69 W	34 N-m (clockwise) 30 N-m (CC)	44 A	75 RPM	un			
Globe Motor (motor only)	--	--	63 W	.21 N-m (30 oz-in)	18.5 A	97 RPM	.82 A			
Globe Motor with drive assembly (gearbox)	117:1	77%	50 W	19 N-m (150 In-lb)	18.5 A	87 RPM +/- 1	.82 A			
Seat Motor	--	--	31 W	2 N-m	20 A	600 RPM	un			
Window Motor (right hand and left hand)	--	--	22 W	12 N-m	20 A	70 RPM	un			
Torque Motor	un	un	~1	>4.0	.11 A	.25 RPM	0.1 A	na	na	na
Chiaphua Motor	--	--	320 W	2.22 N-m	107 A	5,500 RPM	2.3 A	1.11	2750 RPM	55 A
Window Motor (right hand and left hand)	--	--	N/A	8.33 N-m	21 A	85 RPM	3 A	3.43 *	58 RPM *	8.5 *
Johnson Electric, motor	--	--	40.6 W	0.055 N-m	12.5 A	28,000 PRM	.523 A	0.028 N-m	14,040 RPM	6.53 A

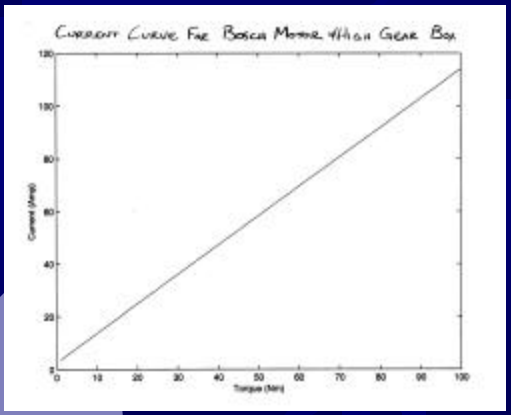
Motor Curves

Speed-Torque Curve



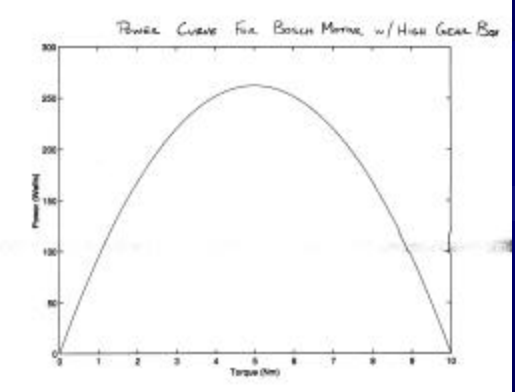
Motor Curves

Current-Torque Curve



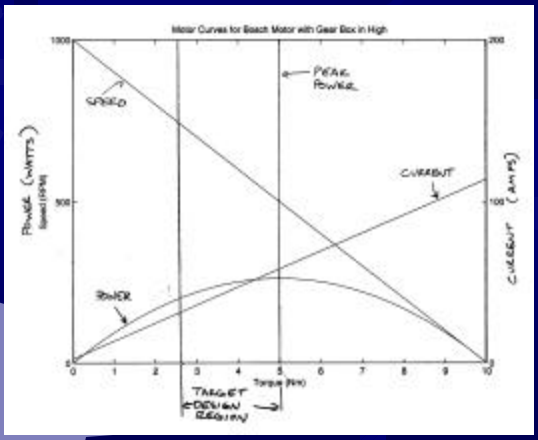
Motor Curves

Power-Torque Curve



Motor Curves

Combined Motor Curves



Calculate Power Required

Power = Torque * Angular Velocity

- Torque = N * meter
  - 1lbs = 4.45 N
  - 1 inch = 0.0254 meters
  - ⇒ 1 in-lbs = 0.11 N-m
- Angular Velocity = rad / sec

  = Free Speed (RPM) * (min/60 sec) * (2 Pi rad / rev)

  ⇒ RPM = 0.1 rad / sec

Credit for Presentation:

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  - Delphi Automotive Systems
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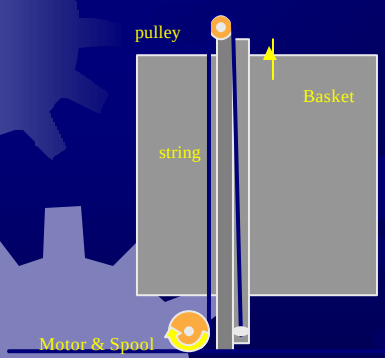
Example for Last Presentation

You have a rough design but need to figure out what motor & size spool you need - see diagram.



Problem: What kind of motor do you need to attach to what size spool?

Given: The basket needs to travel up 3 feet vertically in 5 seconds. The baskets weighs 20 lbs fully loaded with balls

Questions

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Basket Solution

- Power = Force * Distance / time
  - = 20 lbs * 3 feet / 5 secs
  - = 20 lbs * 3 feet * 12 inches / foot / 5 secs
  - = 144 in-lbs / sec
  - = 16 N-m / sec = 16 Watts